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## The failure to act upon important information: where do things go wrong?

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# 6

**Research focus**

The main focus of this thesis is to study 'the failure to apprehend'. The research presented in this thesis is used to verify the model presented in Chapter 5. In order to focus the scope of research, the driving task is used as a framework. In order to design countermeasures that may reduce the number of accidents related to 'the failure to apprehend' during driving, one has to understand the underlying mechanisms and identify the situations under which this phenomenon occurs. In the end, the ultimate goal is to use knowledge about expectations and visual information processing to design roads that force road users to respond to all relevant information.

## 6.1 Difference with CB and IB tasks

Even though the Change Blindness and Inattentional Blindness studies are important lab illustrations of the phenomenon that we are investigating here, it is important to note that there are also large differences between the conditions occurring in these tasks and driving behaviour.

First of all, quite a number of studies have used specific search tasks, with participants being instructed to search for or to focus on some items present in the visual field. However, in more natural tasks, like normal driving, people more or less monitor the scene and are not actively looking for specific information. This means that scanning the environment is done very differently in case of visual search tasks, since instructions are known to affect what items are fixated and therefore selected.

Secondly, there is a difference in the relevance of information between some Change Blindness and Inattentional Blindness tasks and the tasks used in this thesis. In quite some experimental studies, 'the failure to apprehend' is found in case of stimuli that are not that relevant for the task. In Chapter 3 we discussed already that 'the failure to apprehend' may result from an observer not seeing the need to respond if (s)he does not consider it to be relevant for the task. In this thesis, we focus on visual information that is highly relevant for the task.

A third difference between the focus of this thesis and Change Blindness experiments is the need to respond to a change. A specific feature of Change Blindness experiments is that it is the change that needs to be detected, not the information per se. In our daily lives, for example in driving, we are normally not specifically looking for changes in our visual environment but rather respond to what is there. Even in case of dynamic information, such as a traffic light changing from red to green, it is not the change that people have to respond to, it is the presence of the colour green in itself. This is a clear difference with the focus of this thesis.

In this line of reasoning, it is to be expected that 'the failure to apprehend' takes place if one is instructed to attend to something else (as is the case in some Inattentional Blindness experiments). Under those conditions the information is simply not selected. Also, if information is not part of the task that one performs, it is expected that one does not attend and therefore not select that information. It is to be expected that even when information is selected, it is not processed to a deep extent if it does not have any relevance for the task or any informational value in itself. In the current thesis it is therefore important to study tasks in which there is 'the failure to apprehend', most likely induced by expectations, even though the information is relevant for the task at hand. In case of driving, the information we study has to be important from a traffic safety point of view, with 'the failure to apprehend' resulting in safety problems. Also, we want to use a task in which road users are not specifically instructed to search for information. Since selecting and processing driving related items like traffic signs is part of the driving task, traffic signs do have informational value to a driver, and a failure to perceive traffic signs does have negative consequences for the driver, studying traffic signs and responses to traffic signs is a good starting point for studying the phenomenon. Also, detecting a change in a traffic sign or in a traffic situation will not be the main focus of this thesis, but responding to a new traffic sign or traffic situation will. In this case responding to the information that is there is important, and not the mere detection that the information has changed.

## 6.2 Research questions

The idea that 'the failure to apprehend' results from strong (but possibly wrong) expectations, due to a low attention level or due to low task load contrasts with the phenomenon resulting from a (too) high task load. In case of high task load, attentional or visual limitations explain why there is a 'failure to apprehend'; the task is so demanding or the amount of information presented is so high that a person cannot simply process all information available at a sufficient level to generate a response to everything presented. However, in case of strong expectations, low or passive attention and a low task load, limitations in what one can attend or process cannot be the explanation; despite the low effort of the task at hand and despite the fact that there are sufficient attentional resources available, there is 'the failure to apprehend'. The research questions of this dissertation will focus on expectations, inattention and low task load. Conditions of high task load are not discussed in the context of this thesis.

In general, the main research questions are:

1. What is the effect of developing expectations on eye movement behaviour in artificial and driving scenarios (i.e., glance duration to relevant and irrelevant information)?
2. What is the effect of developing expectations on responding to unexpected but relevant information?
3. Are observers able to inhibit a response if expected relevant information turns out to be information that does not require a response?
4. Is there a difference in glance duration between people who respond and those who do not respond to relevant information?
5. Do drivers respond to changes to the traffic situation after they have become familiar with the road environment?
6. Is there a difference in the effect of developing expectations on glance duration of relevant information between real driving and simulated driving?
7. What type of unexpected information does one respond to?
8. How similar does a road environment have be from one encounter to the next in order for road users to develop these expectations?
9. What type of information can help break through these incorrect expectations, resulting in the driver respond to unexpected information?

In order to keep control over what people expect and what they do not expect, all the (driving) tasks used in this thesis allow people to develop the expectations within the experimental task. All tasks used are dynamic tasks.

### 6.3 The experimental studies

The experimental studies of this thesis are a combination of more artificial tasks and driving tasks. Chapter 7 and 8 describe lab tasks that were developed in order to investigate the effect of developing expectations on glancing at relevant and irrelevant information. In these tasks, glance duration and responses to relevant and irrelevant information are measured that is either expected or unexpected. These abstract environments were chosen to study the concept of expectations and responding to

relevant information in a more controlled environment. Since the task of driving is highly trained, people already have a lot of expectations before the experiment starts. Therefore it was important to start from a baseline in which participants did not have prior expectations about the task.

Chapter 9 through 12 focus on the driving task and the traffic environment. The driving task is chosen as a real life task in which expectations, inattention and low task load are represented. In the driving task, responding to driving-related information is of crucial importance. In order to keep some control over expectations, all experiments allow the participant to develop task specific expectations during the experiment.

### **Chapter 7**

Chapter 7 investigates expectations, glances and responses in a laboratory setting. In this study a rather abstract environment was created with a slight overlap with the driving environment. The environment is dynamic, with a flow of visual information approaching the observer (as is also the case in driving). The task of the observers is to decide for each item approaching them whether it is part of the task set (target) or not. By using a new and abstract task environment, observers do not have any expectations yet. This allows expectations to develop under controlled conditions. A large difference with the driving task is that in this task, observers are instructed to respond to specific predefined targets. When driving, the driver normally does not have a specific search task if he is driving in a familiar road environment.

The questions that we address in Chapter 7 are related to the effect of expectations on glancing at relevant and irrelevant information and the effect on responding to unexpected information. The question here is whether glance duration is different in a predictable environment compared to an unpredictable environment. In this study, predictable is defined as 'the order of targets and distractors is predictable'. Even though observers are not instructed that the order is predictable, they are able to develop expectations of when to expect targets and when to expect distractors. The other question that is addressed is: Are targets in the predictable task environment detected if they are not presented according to the predictable scheme and are there costs involved in the predictable condition?

### **Chapter 8**

In Chapter 8, the same type of task environment is used, but with a slightly different task. Again, observers are asked to identify targets and ignore distractors. The effect of expectations is again the topic of this study. Together with the targets and distractors, additional (implicit) information is presented as a cue for an item being a target or a distractor. Observers are not informed about the additional information.

Here, responses to unexpected targets are compared to responses to unexpected distractors. Besides the questions already posed in Chapter 7, extra questions here are: How do people respond to irrelevant information if they expect it to be relevant? Are people able to use this extra information for identifying the targets and distractors? Is there a difference in glance duration between those who respond correctly and those who do not?

## Chapter 9

Chapter 9 describes the first study of this thesis that focuses on the driving task. This driving task is performed in a low-cost driving simulator. By confronting drivers with the same road environment numerous times over numerous days, the expectations that people build up in that task environment are controlled. There are no specific instructions to the participants about what to attend and they are no instructions about the possibility of changing information. Participants are requested to drive as they normally do in their daily drive from home to work.

The route that people are driving in this study contains various intersections, houses, built-up and rural areas and various traffic signs. In this case, glance duration for traffic signs is measured as drivers get more and more familiar with the road. Also, driving speed is measured on the various road sections. In the last drive that participants make, a change is made to the traffic scene (change in priority, highly relevant). It is assessed how drivers, familiar with the environment, respond to this change in the traffic situation (different road markings and traffic sign) compared to people who do not have expectations with this specific task environment yet (glance duration, speed).

## Chapter 10

Chapter 10 continues with the driving task. This study assesses the effect of getting familiar with the driving task on glance duration for traffic related items. Chapter 7, 8 and 9 all use simulated computer task environment, since this allows proper control over the task environment. The question addressed in Chapter 10 is what happens to glance duration when road users get familiar with a specific road environment.

In this study, participants drive a pre-selected route five times per day during a times period of one week. This allows them to get familiar with the road environment while still having some variation from drive to drive in type of traffic and weather conditions. The same route is also recorded on video, also with some variations in traffic and weather. This allows us to study whether glance duration in real driving is comparable to a situation in which participants watch video of the same road environment.

## Chapter 11

Chapter 11 further assesses the expectations that people develop during driving. In this study, we employ a high-end driving simulator. People make various drives on the same road, but variation is made to the environment. The road has the same lay-out, traffic rules, curvature and intersections from drive to drive, but it in some conditions it has a different appearance (more or less trees, buildings, road width etc). After several drives, the traffic situation is changed and responses to this unexpected change are recorded. Responses of drivers in a varied road environment are compared with those in a road environment that always remains the same. Participants also receive different types of information to warn them for the changed situation. This study is also used to test what type of information is most effective in warning the driver.

## Chapter 12

Again the focus is car driving and this time videos are used as stimulus material. The idea here is to study glance duration at traffic signs and to assess what sort of changes to traffic signs are perceived and which ones are not. Videos are made of a drive around the block, showing the video from the perspective of the driver. The videos are made in real traffic, so there are other cars, cyclists, pedestrians. Participants watch the video 5 times before a change is introduced. Participants are instructed to look and verbally respond to a driving related change.

In different conditions, people are confronted with a change of a particular traffic sign. The changes are varied in type of feature change (small changes, large changes) and how well they fit in the scene. Since the participants' task is to watch a video, we are not able to measure a driving response such as reducing speed. Glance duration at the various signs is recorded during the 6 'drives' and all participants are asked if they see any changes. This is asked after the video is stopped, immediately after the change. Glance duration between those who notice and those who do not can be compared. Independently of whether they report the change, they perform a recognition test. Different traffic signs (also the changed sign) are briefly shown and participants have to guess what sign is shown. The idea here is to test if there is better sign recognition for those people who encounter the changed sign. After the test, participants are told what the change has been to determine whether they can recall it after all. In one of the conditions, participants receive an auditory warning just before the change is introduced. This is done to study the effect of attention level on change detection.

## Chapter 13

Chapter 13 discusses the results and makes a link between the literature and the various experiments performed for this thesis. While discussing the experimental results, we draw conclusions and focus on practical applications.



